Appendix C. Internal Representation of Data Types

This appendix contains the detailed internal representations of the PDS standards data types listed in Table 3.2 of the *Data Type Definitions* chapter of this document.

C.1 MSB_INTEGER

Aliases: INTEGER, MAC_INTEGER, SUN_INTEGER

This section describes the signed integers stored in Most Significant Byte first (MSB) order. In this section the following definitions apply:

b0 – b3 Arrangement of bytes as they appear when read from a file (e.g., read b0 first, then b1, b2, and b3)

i-sign Integer sign bit (bit 7 in the highest-order byte

i0 – i3 Arrangement of bytes in the integer, from lowest order to highest order. The bits within each bytes are interpreted from right to left (e.g., lowest value = bit 0, highest value = bit 7) in the following way:

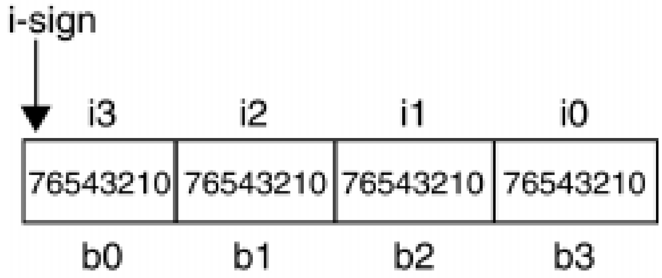
4-byte integers:
In i0, bits 0-7 represent 2**0 through 2**7
In i1, bits 0-7 represent 2**8 through 2**15
In i2, bits 0-7 represent 2**16 through 2**23
In i3, bits 0-6 represent 2**24 through 2**30

2-byte integers:
In i0, bits 0-7 represent 2**0 through 2**7
In i1, bits 0-6 represent 2**8 through 2**14

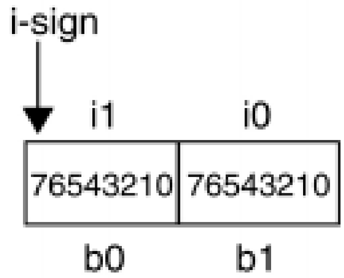
1-byte integers:
In i0, bits 0-6 represent 2**0 through 2**6

Negative integers are represented in two’s complement.

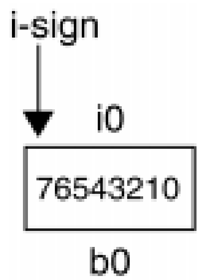
C.1.1 MSB 4-byte Integer



C.1.2 MSB 2-byte Integer



C.1.3 MSB 1-byte Integer



C.2 MSB_UNSIGNED_INTEGER

Aliases: UNSIGNED_INTEGER, MAC_UNSIGNED_INTEGER, SUNS_UNSIGNED_INTEGER

This section describes unsigned integers stored in Most Significant Byte first (MSB) format. In this section the following definitions apply:

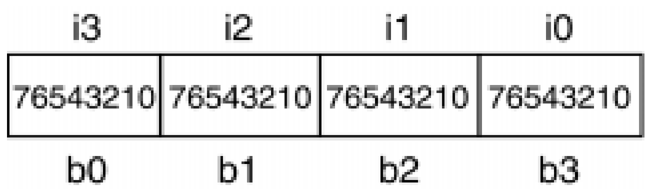
b0 – b3 Arrangement of bytes as they appear when read from a file (e.g., read b0 first, then b1, b2 and b3) *i0 – i3* Arrangement of bytes in the integer, from lowest order to highest order. The bits within each byte are interpreted from right to left (e.g., lowest value = bit 0, highest value = bit 7), in the following way:

4-bytes:
- In i0, bits 0-7 represent 2**0 through 2**7
- In i1, bits 0-7 represent 2**8 through 2**15
- In i2, bits 0-7 represent 2**16 through 2**23
- In i3, bits 0-7 represent 2**24 through 2**31

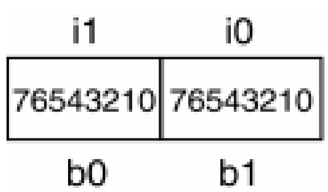
2-bytes:
- In i0, bits 0-7 represent 2**0 through 2**7
- In i1, bits 0-7 represent 2**8 through 2**15

1-byte:
- In i0, bits 0-7 represent 2**0 through 2**7

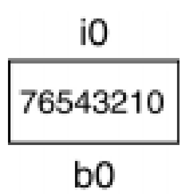
C.2.1 MSB 4-byte Unsigned Integers



C.2.2 MSB 2-byte Unsigned Integers



C.2.3 MSB 1-byte Unsigned Integers



C.3 LSB_INTEGER

Aliases: PC_INTEGER, VAX_INTEGER

This section describes signed integers stored in Least Significant Byte first (LSB) order. In this section the following definitions apply:

b0 – b3 Arrangement of bytes as they appear when reading a file (e.g., read byte b0 first, then b1, b2 and b3)

i-sign Integer sign bit – bit 7 in the highest order byte

i0 – i3 Arrangement of bytes in the integer, from lowest order to highest order. The bits within each bytes are interpreted from right to left (e.g., lowest value = bit 0, highest value = bit 7), in the following way:

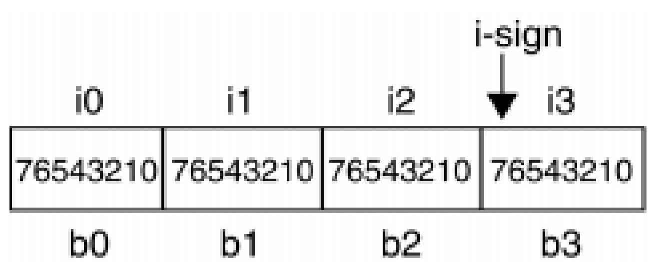
4-bytes:
In i0, bits 0-7 represent 2**0 through 2**7
In i1, bits 0-7 represent 2**8 through 2**15
In i2, bits 0-7 represent 2**16 through 2**23
In i3, bits 0-6 represent 2**24 through 2**30

2-bytes:
In i0, bits 0-7 represent 2**0 through 2**7
In i1, bits 0-6 represent 2**8 through 2**14

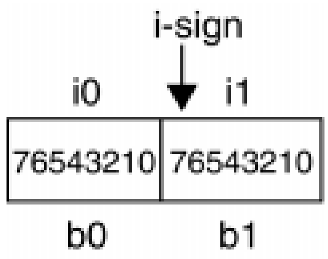
1-byte:
In i0, bits 0-6 represent 2**0 through 2**6

All negative values are represented in two's complement.

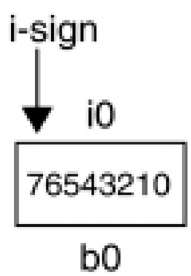
C.3.1 LSB 4-byte Integers



C.3.2 LSB 2-byte Integers



C.3.3 LSB 1-byte Integers



C.4 LSB_UNSIGNED_INTEGER

Aliases: PC_UNSIGNED_INTEGER, VAX_UNSIGNED_INTEGER

This section describes unsigned integers stored in Least Significant Byte first (LSB) format. In this section the following definitions apply:

b0 – b3 Arrangement of bytes as they appear when reading a file (e.g., read byte b0 first, then b1, b2 and b3)

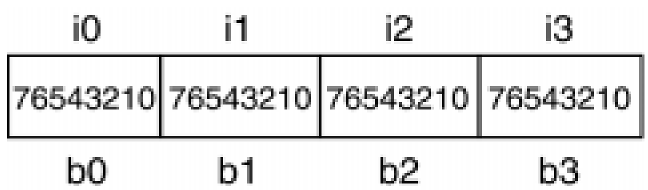
i0 – i3 Arrangement of bytes in the integer, from lowest order to highest order. The bits within each bytes are interpreted from right to left (e.g., lowest value = bit 0, highest value = bit 7), in the following way:

4-bytes:
In i0, bits 0-7 represent 2**0 through 2**7
In i1, bits 0-7 represent 2**8 through 2**15
In i2, bits 0-7 represent 2**16 through 2**23
In i3, bits 0-7 represent 2**24 through 2**31

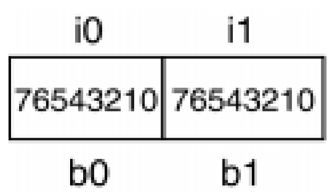
2-bytes:
In i0, bits 0-7 represent 2**0 through 2**7
In i1, bits 0-7 represent 2**8 through 2**15

1-byte:
In i0, bits 0-7 represent 2**0 through 2**7

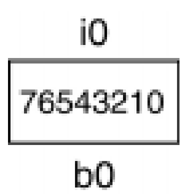
C.4.1 LSB 4-byte Unsigned Integers



C.4.2 LSB 2-byte Unsigned Integers



C.4.3 LSB 1-byte Unsigned Integers



C.5 IEEE_REAL

Aliases: FLOAT, REAL, MAC_REAL, SUN_REAL

This section describes the internal format of IEEE-format floating-point numbers. In this section the following definitions apply:

b0 – b9 Arrangement of bytes as they appear when read from a file (e.g., read b0 first, then b1, b2, b3, etc.)

m-sign Mantissa sign bit

int-bit In 10-byte real format only, the integer part of the mantissa, assumed to be "1" in other formats, is explicitly indicated by this bit

e0 – e1 Arrangement of the portions of the bytes that make up the exponent, from lowest order to highest order. The bits within each byte are interpreted from right to left (e.g., lowest value = rightmost bit in the exponent part of the byte, highest value = leftmost bit in the exponent part of the byte) in the following way:

10-bytes (temporary):
In e0, bits 0-7 represent 2**0 through 2**7
In e1, bits 0-6 represent 2**8 through 2**14

Exponent bias = 16383

8-bytes (double precision):
In e0, bits 4-7 represent 2**0 through 2**3
In e1, bits 0-6 represent 2**4 through 2**10

Exponent bias = 1023

4-bytes (single precision):
In e0, bit 7 represent 2**0
In e1, bits 0-6 represent 2**1 through 2**7

Exponent bias = 127

m0 – m7 Arrangement of the portions of the bytes that make up the mantissa, from highest order fractions to the lowest order fraction. The order of the bits within each byte progresses from left to right, with each bit representing a fractional power of two, in the following way:

10-bytes (temporary):
In m0, bits 6-0 represent 1/2**1 through 1/2**7
In m1, bits 7-0 represent 1/2**8 through 1/2**15
In m2, bits 7-0 represent 1/2**16 through 1/2**23
In m3, bits 7-0 represent 1/2**24 through 1/2**31
In m4, bits 7-0 represent 1/2**32 through 1/2**39
In m5, bits 7-0 represent 1/2**40 through 1/2**47
In m6, bits 7-0 represent 1/2**48 through 1/2**55
In m7, bits 7-0 represent 1/2**56 through 1/2**63

8-bytes (double precision):
- In m0, bits 3-0 represent 1/2**1 through 1/2**4
- In m1, bits 7-0 represent 1/2**5 through 1/2**12
- In m2, bits 7-0 represent 1/2**13 through 1/2**20
- In m3, bits 7-0 represent 1/2**21 through 1/2**28
- In m4, bits 7-0 represent 1/2**29 through 1/2**36
- In m5, bits 7-0 represent 1/2**37 through 1/2**44
- In m6, bits 7-0 represent 1/2**45 through 1/2**52

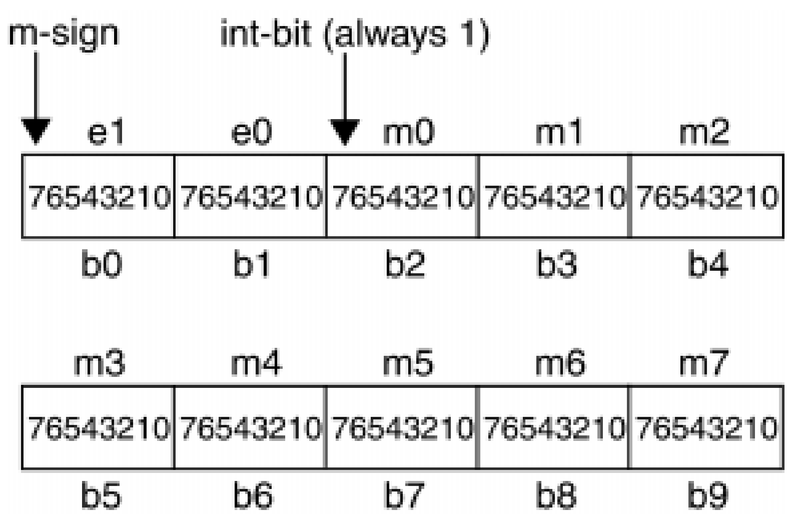
4-bytes (single precision):
- In m0, bits 6-0 represent 1/2**1 through 1/2**7
- In m1, bits 7-0 represent 1/2**8 through 1/2**15
- In m2, bits 7-0 represent 1/2**16 through 1/2**23

The following representations all follow this format:

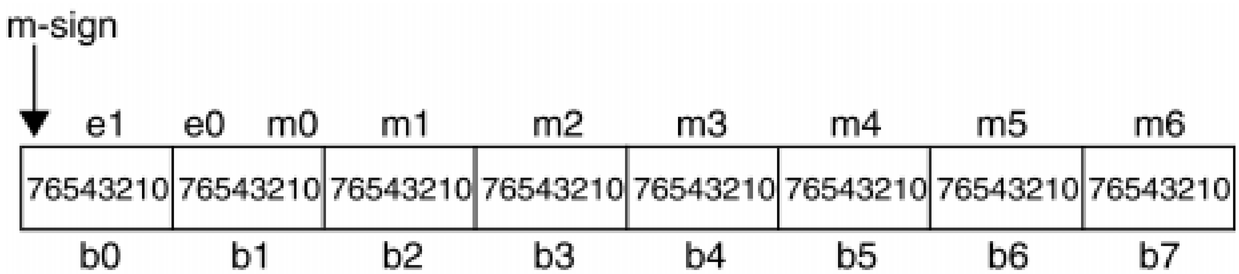
$$1.\textit{mantissa} \times 2^{**}(\textit{exponent} - \textit{bias})$$

Note that the integer part ("1.") is implicit in all formats except the 10-byte (temporary) real format, as described above. In all cases the exponent is stored as an unsigned, biased integer (that is, the stored exponent value – bias value = true exponent).

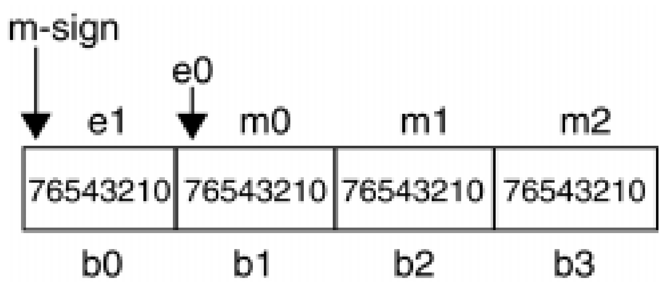
C.5.1 IEEE 10-byte (Temporary) Real Numbers



C.5.2 IEEE 8-byte (Double Precision) Real Numbers



C.5.3 IEEE 4-byte (Single Precision) Real Numbers



C.6 IEEE_COMPLEX

Aliases: COMPLEX, MAC_COMPLEX, SUN_COMPLEX

IEEE complex numbers consist of two IEEE_REAL format numbers of the same precision, contiguous in memory. The first number represents the real part and the second the imaginary part of the complex value.

C.7 PC_REAL

Aliases: None

This section describes the internal storage format corresponding to the PC_REAL data type. In this section the following definitions apply:

b0 – b9 Arrangement of bytes as they appear when read from a file (e.g., read b0 first, then b1, b2 and b3)

m-sign Mantissa sign bit

int-bit In 10-byte real format only, the integer part of the mantissa, assumed to be "1" in other formats, is explicitly indicated by this bit.

e0 – e1 Arrangement of the portions of the bytes that make up the exponent, from lowest order to highest order. The bits within each byte are interpreted from right to left (e.g., lowest value = rightmost bit in the exponent part of the byte, highest value = leftmost bit in the exponent part of the byte) in the following way:

10-bytes (temporary):
In e0, bits 0-7 represent 2**0 through 2**7
In e1, bits 0-6 represent 2**8 through 2**14

Exponent bias = 16383

8-bytes (double precision):
In e0, bits 4-7 represent 2**0 through 2**3
In e1, bits 0-6 represent 2**4 through 2**10

Exponent bias = 1023

4-bytes (single precision):
In e0, bit 7 represent 2**0
In e1, bits 0-6 represent 2**1 through 2**7

Exponent bias = 127

m0 – m7 Arrangement of the portions of the bytes that make up the mantissa, from highest order fractions to the lowest order fraction. The order of the bits within each byte progresses from left to right, with each bit representing a fractional power of two, in the following way:

10-bytes (temporary):
In m0, bits 6-0 represent 1/2**1 through 1/2**7
In m1, bits 7-0 represent 1/2**8 through 1/2**15
In m2, bits 7-0 represent 1/2**16 through 1/2**23
In m3, bits 7-0 represent 1/2**24 through 1/2**31
In m4, bits 7-0 represent 1/2**32 through 1/2**39
In m5, bits 7-0 represent 1/2**40 through 1/2**47
In m6, bits 7-0 represent 1/2**48 through 1/2**55
In m7, bits 7-0 represent 1/2**56 through 1/2**63

8-bytes (double precision):
In m0, bits 3-0 represent 1/2**1 through 1/2**4
In m1, bits 7-0 represent 1/2**5 through 1/2**12
In m2, bits 7-0 represent 1/2**13 through 1/2**20
In m3, bits 7-0 represent 1/2**21 through 1/2**28
In m4, bits 7-0 represent 1/2**29 through 1/2**36
In m5, bits 7-0 represent 1/2**37 through 1/2**44
In m6, bits 7-0 represent 1/2**45 through 1/2**52

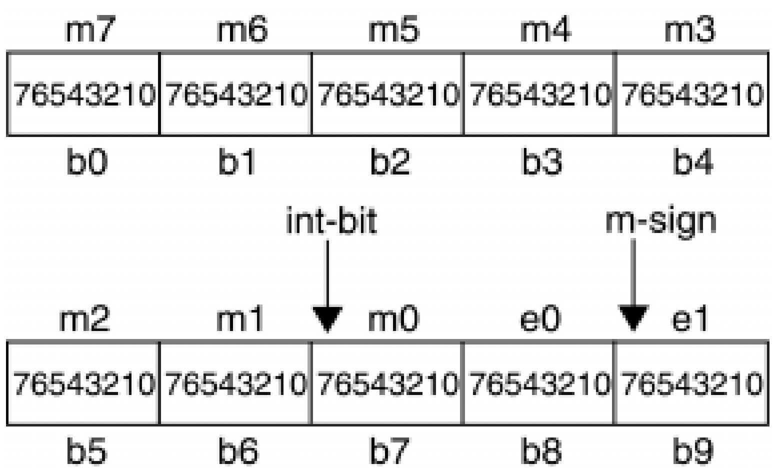
4-bytes (single precision):
In m0, bits 6-0 represent 1/2**1 through 1/2**7
In m1, bits 7-0 represent 1/2**8 through 1/2**15
In m2, bits 7-0 represent 1/2**16 through 1/2**23

The following representations all follow this format:

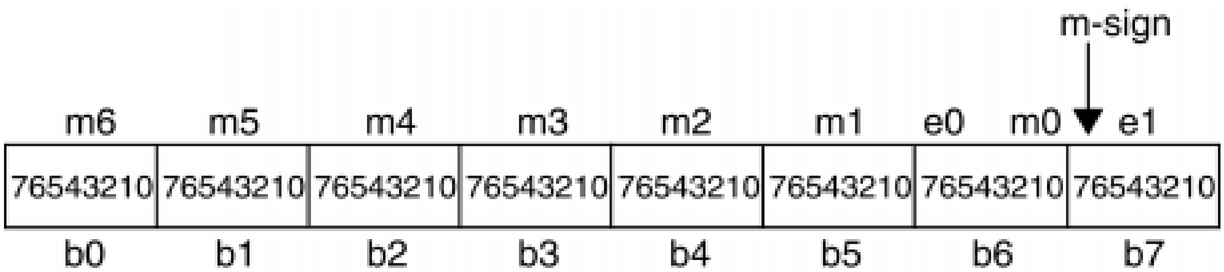
$$1.\mathit{mantissa} \times 2^{**}(\mathit{exponent} - \mathit{bias})$$

Note that the integer part ("1.") is implicit in all formats except the 10-byte (temporary) real format, as described above. In all cases the exponent is stored as an unsigned, biased integer (that is, the stored exponent value – bias value = true exponent).

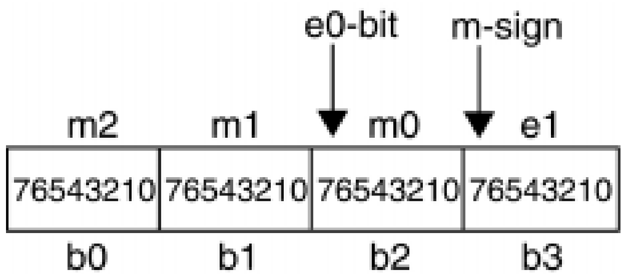
C.7.1 PC 10-byte (Temporary) Real Numbers



C.7.2 PC 8-byte (Double Precision) Real Numbers



C.7.3 PC 4-byte (Single Precision) Real Numbers



C.8 PC_COMPLEX

Aliases: None

PC complex numbers consist of two PC_REAL format numbers of the same precision, contiguous in memory. The first number represents the real part and the second the imaginary part of the complex value.

C.9 VAX_REAL, VAXG_REAL

Aliases: VAX_DOUBLE for VAX_REAL only. No aliases for VAXG_REAL

This section describes the internal format corresponding to the VAX_REAL and VAXG_REAL data types. In this section the following definitions apply:

b0 – b15 Arrangement of bytes as they appear when read from a file (e.g., read b0 first, then b1, b2 and b3)

m-sign Mantissa sign bit

e0 – e1

Arrangement of the portions of the bytes that make up the exponent, from lowest order to highest order. The bits within each byte are interpreted from right to left (e.g., lowest value = rightmost bit in the exponent part of the byte, highest value = leftmost bit in the exponent part of the byte) in the following way:

16-bytes (H-type, quad precision):
In e0, bits 0-7 represent 2**0 through 2**7
In e1, bits 0-6 represent 2**8 through 2**14

Exponent bias = 16385

8-bytes (G-type, double precision):
In e0, bits 4-7 represent 2**0 through 2**3
In e1, bits 0-6 represent 2**4 through 2**10

Exponent bias = 1025

8-bytes (D-type, double precision):
In e0, bit 7 represents 2**0
In e1, bits 0-6 represent 2**1 through 2**7

Exponent bias = 129

4-bytes (F-type, single precision):
In e0, bit 7 represent 2**0
In e1, bits 0-6 represent 2**1 through 2**7

Exponent bias = 129

m0 – m13

Arrangement of the portions of the bytes that make up the mantissa, from highest order fractions to the lowest order fraction. The order of the bits within each byte progresses from left to right, with each bit representing a fractional power of two, in the following way:

16-bytes (H-type, quad precision):
In m0, bits 7-0 represent 1/2**1 through 1/2**8
In m1, bits 7-0 represent 1/2**9 through 1/2**16
In m2, bits 7-0 represent 1/2**17 through 1/2**24
In m3, bits 7-0 represent 1/2**25 through 1/2**32
In m4, bits 7-0 represent 1/2**33 through 1/2**40
In m5, bits 7-0 represent 1/2**41 through 1/2**48
In m6, bits 7-0 represent 1/2**49 through 1/2**56
In m7, bits 7-0 represent 1/2**57 through 1/2**64
In m8, bits 7-0 represent 1/2**65 through 1/2**72
In m9, bits 7-0 represent 1/2**73 through 1/2**80

In m10, bits 7-0 represent 1/2**81 through 1/2**88
In m11, bits 7-0 represent 1/2**89 through 1/2**96
In m12, bits 7-0 represent 1/2**97 through 1/2**104
In m13, bits 7-0 represent 1/2**105 through 1/2**112

8-bytes (G-type, double precision):
In m0, bits 3-0 represent 1/2**1 through 1/2**4
In m1, bits 7-0 represent 1/2**5 through 1/2**12
In m2, bits 7-0 represent 1/2**13 through 1/2**20
In m3, bits 7-0 represent 1/2**21 through 1/2**28
In m4, bits 7-0 represent 1/2**29 through 1/2**36
In m5, bits 7-0 represent 1/2**37 through 1/2**44
In m6, bits 7-0 represent 1/2**45 through 1/2**52

8-bytes (D-type, double precision):
In m0, bits 6-0 represent 1/2**1 through 1/2**7
In m1, bits 7-0 represent 1/2**8 through 1/2**15
In m2, bits 7-0 represent 1/2**16 through 1/2**23
In m3, bits 7-0 represent 1/2**24 through 1/2**31
In m4, bits 7-0 represent 1/2**32 through 1/2**39
In m5, bits 7-0 represent 1/2**40 through 1/2**47
In m6, bits 7-0 represent 1/2**48 through 1/2**55

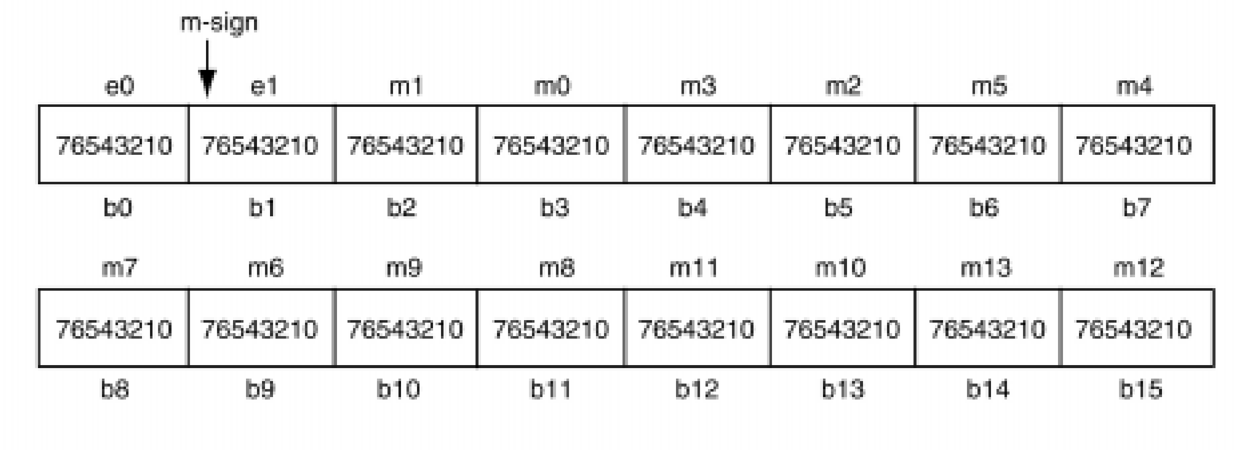
4-bytes (F-type, single precision):
In m0, bits 6-0 represent 1/2**1 through 1/2**7
In m1, bits 7-0 represent 1/2**8 through 1/2**15
In m2, bits 7-0 represent 1/2**16 through 1/2**23

The following representations all follow this format:

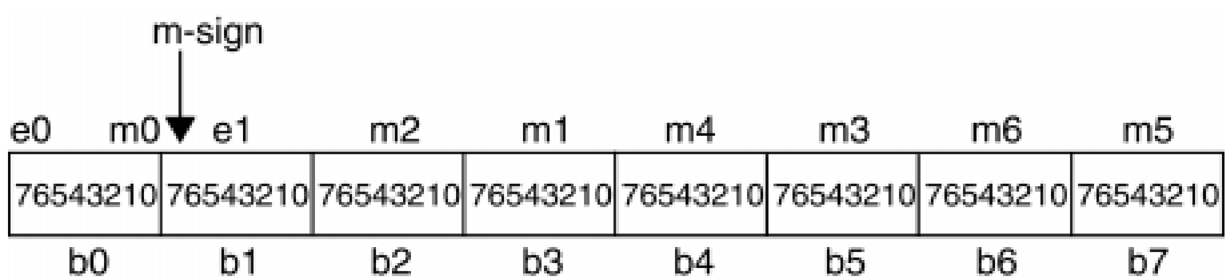
$$1.\mathit{mantissa} \times 2{**}(\mathit{exponent} - \mathit{bias})$$

Note that the integer part ("1.") is implicit in all formats except the 10-byte (temporary) real format, as described above. In all cases the exponent is stored as an unsigned, biased integer (that is, the stored exponent value – bias value = true exponent).

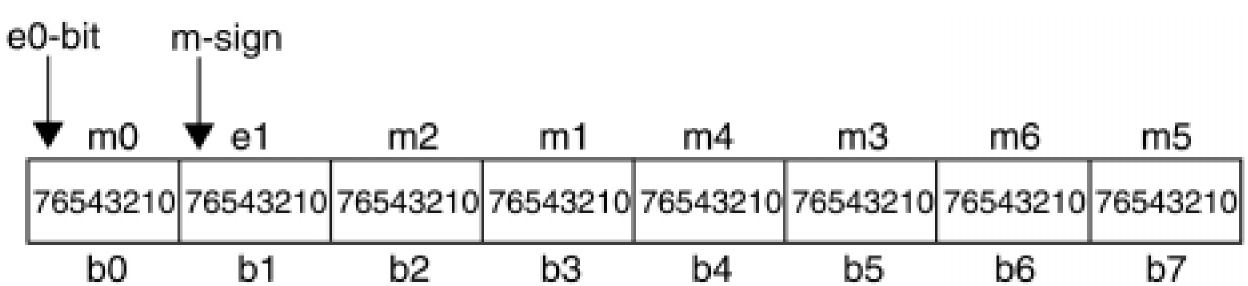
C.9.1 VAX 16-byte H-type (Quad Precision) Real Numbers



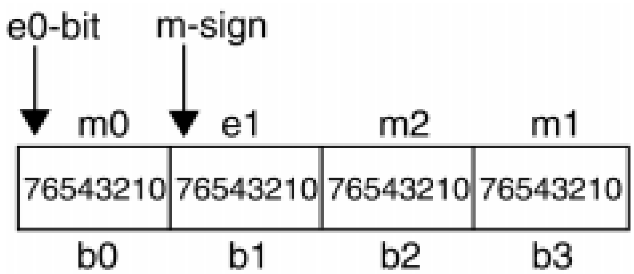
C.9.2 VAX 8-byte G-type (Double Precision) Real Numbers



C.9.3 VAX 8-byte D-type (Double Precision) Real Numbers



C.9.4 VAX 4-byte F-type (Single Precision) Real Numbers



C.10 VAX_COMPLEX, VAXG_COMPLEX

Aliases: None

VAX complex numbers consist of two VAX_REAL (or VAXG_REAL) format numbers of the same precision, contiguous in memory. The first number represents the real part and the second the imaginary part of the complex value.

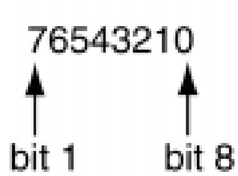
C.11 MSB_BIT_STRING

Aliases: None

This section describes the storage format for bit strings stored in Most Significant Byte first (MSB) format. In this section the following definitions apply:

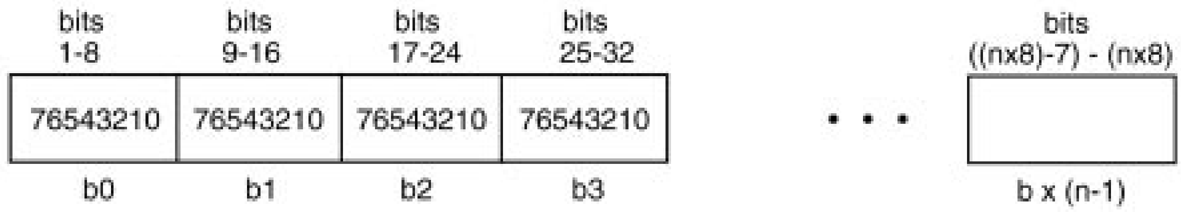
b0 – b3 Arrangement of bytes as they appear when read from a file (e.g., read b0 first, then b1, b2 and b3)

The bits within a byte are numbered from left to right, as shown below:



Note that in the case of MSB bit strings, no byte-swapping is required. That is, the physical storage order of the bytes is identical to the logical order.

C.11.1 MSB *n*-byte Bit Strings



C.11.2 MSB 2-byte Bit String

Figure Missing

C.11.3 MSB 1-byte Bit String

C.12 LSB_BIT_STRING

Aliases: VAX_BIT_STRING

This section describes the structure of bit strings stored in Least Significant Byte first (LSB) order. In this section, the following definitions apply:

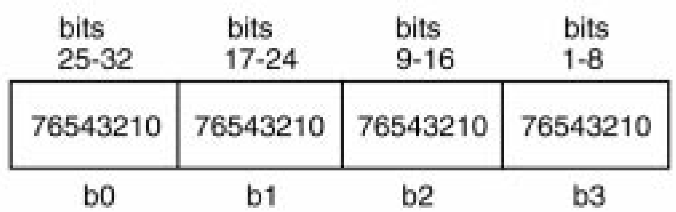
b0 – b3 Arrangement of bytes as they appear when read from a file (e.g., read b0 first, then b1, b2 and b3)

The bits within a byte are numbered from left to right, as shown below:

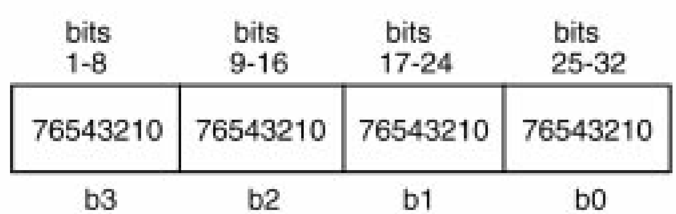
Note that for LSB bit strings byte-swapping is required to convert the storage order of bytes to the logical order.

C.12.1 LSB 4-byte Bit String

Physical order (as read from the file):

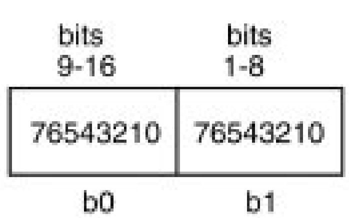


Logical order (after byte-swapping):

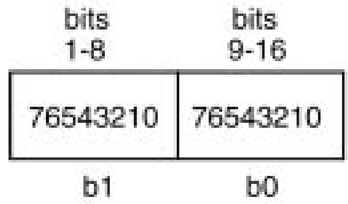


C.12.2 LSB 2-byte Bit String

Physical order (as read from the file):



Logical order (after byte-swapping):



C.12.3 LSB 1-byte Bit String

Note that in this degenerate case no byte-swapping is required.